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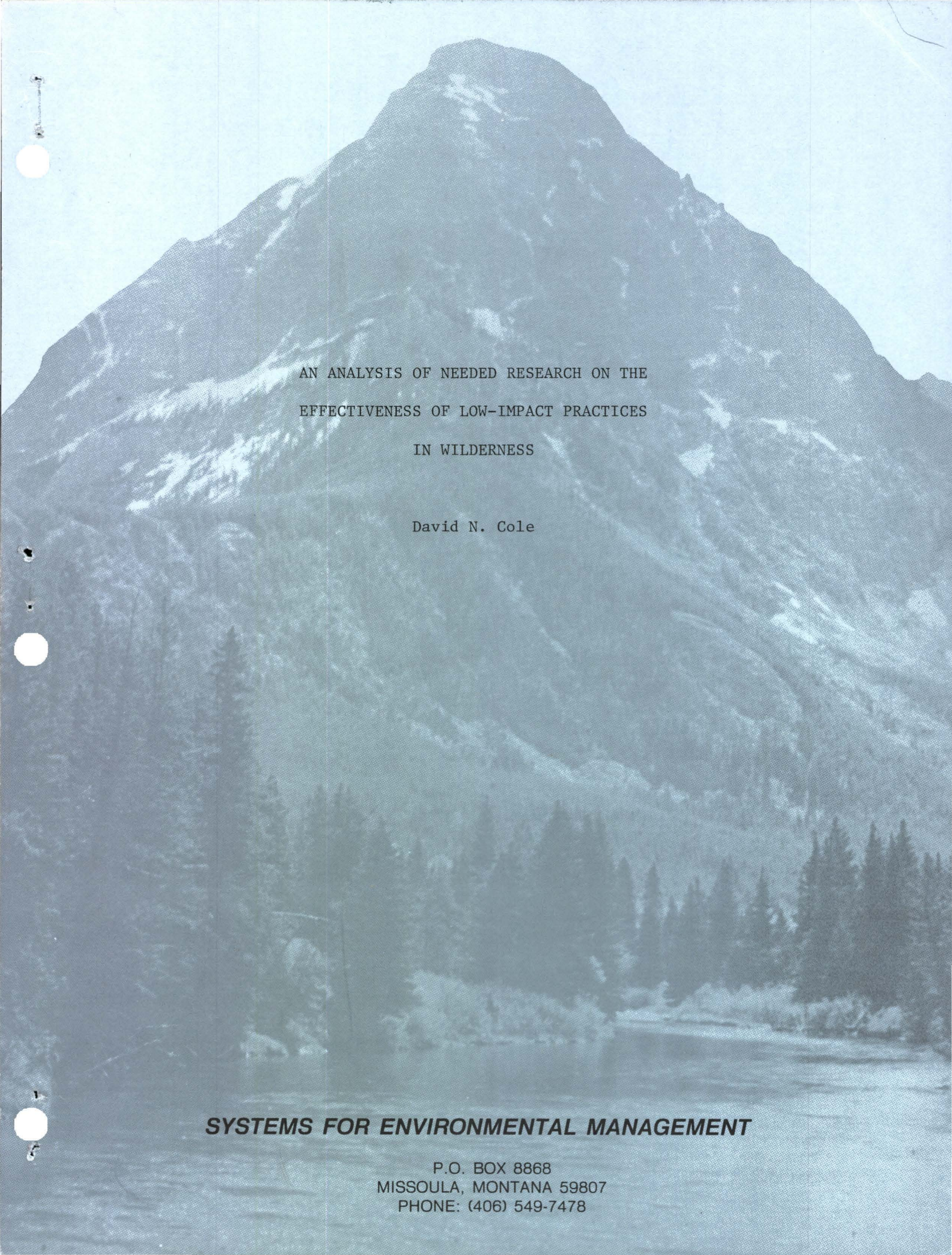
An Analysis of Needed Research on the Effectiveness of Low-Impact Practicies in Wilderness



AN ANALYSIS OF NEEDED RESEARCH ON THE EFFECTIVENESS OF LOW-IMPACT PRACTICES IN WILDERNESS

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INTRODUCTION

Increasing use of the backcountry is taking a heavy toll. The ecological integrity of the land is suffering and it is becoming increasingly difficult to find solitude in the wilds. The major tool available to combat this trend--outside of directly limiting access to the backcountry and prohibiting many of the activities that make backcountry experiences free and joyful--is to get every visitor to voluntarily minimize the impact of his/her visit. Educating visitors in low-impact backcountry use is one of the keys to perpetuation of both the ecological and experiential qualities of wilderness.

The history of the low-impact-education movement is difficult to trace. Many people have instinctively practiced and taught others low-impact techniques. Although the pack-it-in, pack-it-out anti-litter campaign was an early attempt by the public land-managing agencies to affect behavioral change, these agencies have only recently been recommending a comprehensive set of low-impact practices.

Today the concept of low-impact education is well-accepted. Techniques are taught in "how-to" books (e.g. Petzoldt 1974, Hart 1977, Simer and Sullivan 1983), books specifically on low-impact camping (e.g. Waterman and Waterman 1979), popular articles (e.g. Manning 1980, Hart 1980, Wallace and DeBell 1982, Curtis 1982) and in brochures and presentations put together by land-managing agencies and user groups (e.g. Recreational Equipment Incorporated and Backcountry Horsemen). Although much thought has gone into the development of techniques, there has been little formal evaluation of accuracy or effectiveness. In fact, an examination of recommended practices often uncovers conflicting recommendations.

This report consists of two parts. The first part identifies research gaps--places where further research would improve the consistancy and effectiveness of low impact practices. The second part identifies specific research questions and approaches for filling in these gaps.

In order to identify research gaps I conducted relatively thorough examinations of both the low-impact literature and research on ecological impacts, their causes and mitigation measures. The low-impact literature was consulted to determine whether or not there was a consensus of opinion on low-impact recommendations. Practices that were not universally accepted were identified. Generally these controversial practices were separated into two categories. With some techniques we need additional information to evaluate different opinions; existing research is simply inadequate. For example, differences of opinion about the most durable locations for campsites will only be resolved by understanding more about which sites are and are not durable. For these techniques a knowledge gap exists and research is called for.

Other differences of opinion result from trying to make general statements about practices that are appropriate in some situations but not in others. These differences can be eliminated by more precisely defining where a given practice is or is not effective. For example, controversy over whether or not it is desirable to eliminate all firerings will not be solved through research. We already know enough to evaluate the consequences of leaving or removing firerings in various situations. A firering is desirable on a site where use and impact is being concentrated in order to minimize the areal spread of impact (this is often the most effective means of controlling impact in high-use areas). The firering encourages campers to use the same site over and over and it also limits campfire impact to only a small portion of the site. On the other hand, a firering should never be left on sites in areas where concentration of use is discouraged. Such sites will deteriorate rapidly if used very often and a firering is likely to encourage repeat use.

For some practices, there was consensus about a given technique, but there is evidence that (a) the technique may have some negative consequences, (b) the technique may not be that important, at least in some situations, or (c) that we need more information to evaluate or refine the technique. Some of these issues also require further research.

NONCONTROVERSIAL TECHNIQUES NOT REQUIRING FURTHER RESEARCH

Practices that are generally agreed upon and for which there is little evidence that they need further evaluation are described below. They have been subdivided into the following classes: (1) general conduct--behavior that applies regardless of where you are in the backcountry; (2) hiking and riding behavior--applicable primarily to when visitors are on the move; (3) campsite selection; (4) camping behavior; (5) behavior specific to the use of campfires; (6) behavior specific to the disposal of wastes, including human waste; and (7) handling and use of stock.

General Conduct

1. Choose colors--for clothes, sleeping bags, packs and particularly tents--that blend into the surroundings. This will minimize the likelihood of other parties seeing you and your camp and, thereby, reduce perceived crowding.

2. Keep group size small. Although this is appropriate everywhere it is particularly important when travelling off-trail, camping on previously-undisturbed sites, and visiting little-used and disturbed places--because such places can be disturbed rapidly and it is easier for a small party to minimize impact. The smaller the group the better, although safety must also be considered. Attempts to recommend specific maxima are inherently arbitrary and contradictory.

3. Be as quiet as possible, except when travelling in grizzly bear country. This will minimize disturbance of other visitors and possibly wildlife.

4. Keep pets under restraint. They should not be allowed to harass wildlife or other visitors. Some have argued that pets are not appropriate in wilderness.

5. Do not intentionally disturb natural or cultural features. Do not cut or deface trees, dead or alive, and avoid scarring downed logs unnecessarily. Avoid moving rocks or picking wildflowers and use restraint when collecting edible plants. Never disturb historical artifacts or antiquities. Although the best policy is clearly to minimize all unnecessary disturbance, it is difficult to precisely define how strict to be about such disturbances as picking wildflowers and chopping downed logs for firewood.

Several other suggestions deal with items either to carry or not to carry. Suggested items to carry include stoves, tents with integral frames and waterproof floors, trashbags, waterbags, plastic containers for food--so excess food and non-disposable waste is minimized, and a shovel or trowel. Suggested items not to take include axes and saws, lug-soled boots, shovels, firearms, cans, bottles and other non-disposable items and pets. Some of these are controversial.

A final suggestion is likely to lead to some positive effects, but it also raises the possibility of some negative side-effects. This is the suggestion to avoid visiting popular places during popular times, either seasons or days of the week. While there are no likely negative side-effects of visiting during low-use days of the week, shifting use to different seasons can shift it to times when the environment is more fragile or to times that currently offer outstanding opportunities for solitude. Similarly shifting use to less popular places means shifting it to places that are more prone to disturbance (because they have not yet been substantially impacted) and that currently offer outstanding opportunities for solitude. If only a few people follow this suggestion, they may or may not benefit (depending upon their preferences) and there are likely to be no major positive or negative effects. If a sizeable proportion of people follow this suggestion, however, both positive and negative consequences could be sizeable.

Hiking or Riding Behavior

1. When hiking/riding on established trails stay in the center of the main tread. Go single-file, rather than abreast. Avoid the edge of the trail and adjacent treads. Do not shortcut switchbacks. Go through muddy stretches and over snowbanks, rather than around them. Make every attempt to concentrate your impact on the already-impacted trail tread.

2. When hikers meet a stock party, allow them plenty of room. Move off the trail, if possible the downhill side and stand quietly until the party passes.

3. Avoid use of trails during seasons when they are muddy.

4. When taking a break along the trail, choose a durable location. If you can leave the trail without causing undue disturbance, take the break away from the trail, where other parties can pass by without contact.

5. Sweep stock manure off the trail where it will not disturb other visitors.

6. When travelling cross-country, keep party size small and avoid the use of stock. Spread out so that not everyone is following the same route. Do not blaze trees, build cairns or leave messages in the dirt.

Campsite Selection

1. Choose a campsite that is off the trail and away from other parties, to minimize contact with other groups. Selection of a site away from water and "beauty spots" can make this easier. Sites that are concealed and in places where noise is not readily transmitted are particularly good choices.

2. When selecting an existing campsite, choose one that is large enough for your party, one that does not need to be expanded to accommodate all of the people in your group.

Campsite Behavior

1. Set up camp early enough so that an appropriate site can be found and care can be taken to avoid impact while setting up camp.

2. Minimize engineering of the site--building structures, clearing sleeping areas of rocks, twigs or pinecones. Dismantle any structures you constructed and replace any moved items when leaving. Do not ditch tents.

3. Avoid trampling vegetation, particularly tree seedlings in camp.

Use of Campfires

1. Use of stoves is always preferable to having a campfire. Campfires are particularly inappropriate where firewood is not plentiful (e.g. at or above timberline and in many deserts) and where risk of wildfire is high.

2. Collect only small pieces of dead and down wood for use in fires. Gather wood some distance from camp; do not take all of the available wood in one place; and avoid stripping the bark off trees.

3. Keep fires small. Never build fires in duff; always build them far from tents, trees, branches, root systems and large rocks that might be damaged by sparks and heat or blackened by smoke. Do not ring fire with rocks.

4. Stop adding wood long before finishing with the fire. Burn coals down to ash and soak ashes.

5. Scatter excess firewood.

Waste Disposal and Sanitation

1. Carry out all unburnable litter. Minimize the need to burn litter and avoid burning excess food. Carry out as much of other people's litter as you can.

2. Drain waste water, from washing dishes or excess cooking water, away from water bodies. Drain off large quantities away from campsites; small quantities can be disposed of in the corner of a firepit. Pick up and pack out as many excess food scraps as possible.

3. Minimize the use of soap. Always bathe and dispose of soapy water away from water bodies. Attempts to define a minimum distance from water are inherently arbitrary and have been contradictory. Disposal must be far enough away so that soap breaks down before entering the water. Breakdown is facilitated if biodegradable soaps are used.

4. Use toilets or latrines if they are available.

5. If not, deposit feces in a cat-hole, about 6 inches deep, located far from water bodies, campsites or trails, in places unlikely to be used by others.

6. It is best to pack out toilet paper and tampons (except in bear country). In some places it is safe to burn them.

7. It is best to urinate away from trails, campsites and water bodies.

Use of Stock

1. Use properly-trained stock that are less likely to inflict unnecessary damage than stock that are ill-at-ease in the wilderness.

2. Minimize the number of stock, by carrying lightweight equipment.

3. If giving stock supplemental feed, do not feed stock or give them salt directly on the ground.

4. Cut out trail obstacles, rather than going around them and creating a new trail.

5. Keep stock away from water bodies, except to drink. Water stock downstream from commonly-used sources of drinking water for humans, on a durable site.

6. Do not "loose trail" stock.

7. When confining stock, use existing facilities, such as hitchrails and corrals, if they are available.

8. Keep stock out of camp areas. Scatter any manure in camp areas.

9. Horses should be shod with flat plates, which have less tendency to dig up the ground than shoes with heel or toe caulks. Take along insect repellent and fringed eye guards, so that stock will be less disturbed by insects and less prone to paw the soil.

NONCONTROVERSIAL TECHNIQUES REQUIRING FURTHER RESEARCH

A number of practices are agreed upon in general, but either (1) the effectiveness of the technique has never been evaluated, or (2) we need more information to make the technique effective.

General Conduct

1. Avoid disturbance of wildlife. While this is obvious, we know so little about the impacts of recreationists on wildlife that we cannot provide much guidance to visitors. Feeding wildlife is obviously to be avoided. It is also clearly important to not chase or scare wildlife and to be particularly careful around birthing, nesting, feeding and watering sites, as well as during seasons, such as winter, when animals are already stressed. But it is not clear what situations are most critical and how harassment is best avoided.

Camping Behavior

1. Wear soft-soled shoes around the camp to minimize damage to soil and vegetation. Some also recommend not wearing lug-soled boots even while hiking. While there is no controversy about this suggestion, limited research suggests that soft-soled shoes are as damaging as lug-soled boots.

2. Move camp frequently enough to avoid damage. A corollary is to move tent and kitchen locations frequently enough to avoid damage. While this is not a controversial suggestion, we need more information about how frequently rotation should occur in various situations. Clearly rotation should be more frequent in more fragile environments and in places that have not been disturbed previously.

Use of Campfires

1. Build a fire in a place and manner that will minimize damage. A number of fire-building techniques have been suggested. There is surprisingly little controversy about these, given that there has been no evaluation of success and the potential for substantial resource damage is high.

Waste Disposal and Sanitation

1. Deposit human waste where it will decompose rapidly. While this is certainly not controversial, we know almost nothing about how to maximize decomposition rates.

Use of Stock

1. Rotate stock frequently, so they do not overgraze available forage, causing deterioration of range or loss of forage needed by wildlife. There is no controversy, but few data are available to provide more definitive suggestions.

2. Bring in some supplemental feed to use where needed. Again there is no controversy, but more research would provide more definitive guidelines on where use of supplemental feed is needed.

CONTROVERSIAL TECHNIQUES NOT REQUIRING FURTHER RESEARCH

These techniques are not generally accepted. But the major cause of disagreement appears to be trying to make broad generalizations where this is impossible. The disagreement is always about techniques that are direct opposites. Usually one thing is appropriate in one situation, while its opposite is appropriate elsewhere. These differences can be resolved by more precisely defining where a given practice is or is not effective. This can generally be done on the basis of existing research; little additional research is needed.

Hiking and Riding Behavior

1. Avoid existing trails vs. use existing trails. This could apply to both hikers and stock or just to stock. Research results suggest that impacts on wildlife, soil and vegetation will be minimized by walking on constructed trails that are already highly disturbed and, in many cases, designed to accommodate heavy use. Use of existing trails does increase contacts with other visitors, but cross-country hiking in popular places is likely to lead to the creation of undesired trails. The most appropriate recommendation is probably to use existing trails, unless your party is small and trained in low-impact techniques and fragile areas can be avoided.

Campsite Selection

1. Use existing campsites vs. select an unused site. Other variations include not using lightly-impacted sites, severely-impacted sites, heavily-used campsites or old, established campsites. Research results show that impact is minimized when a party selects either (1) an apparently unimpacted site (if it is resistant, not located close to popular places where it might receive repeat use and if the party is capable of leaving little impact) or (2) a site that is so highly impacted that further use will cause no additional impact (Cole and Benedict 1983).

Campsite Behavior

1. Disperse tents and activities on and around the campsite vs. do not sprawl out; concentrate activities on already impacted areas. The appropriateness of these recommendations depends upon the level of pre-existing impact. On a pristine site, it is best to disperse tents and activities (and important not to stay too long). On sites that are already well-impacted, it is best to confine activities to already impacted areas, because further deterioration of these places is likely to be minimal, while expansion of impact is possible.

Use of Campfires

1. Use existing firerings vs. build a low-impact fire on an undisturbed site. Again the appropriateness of these recommendations depends upon the level of pre-existing impact. Use of existing firerings is more appropriate in popular areas that have been well-impacted. It is appropriate where repetitive use of sites is desired. Building fires in new places is appropriate in lightly-used places where evidence of impact is minimal. It is appropriate where repetitive use of sites is discouraged.

2. Dismantle firerings vs. leave firerings. This is obviously related to the preceding controversy. Firerings should be dismantled where repetitive use is discouraged. This is likely to be appropriate where use is low and disturbance has been minimal. In popular areas, it is likely to cause a proliferation of firerings and it is preferable for campers to leave one clean and attractive firering on each site. This will encourage repetitive use and will concentrate campfire impact in one place.

CONTROVERSIAL TECHNIQUES REQUIRING FURTHER RESEARCH

These are techniques that are not agreed on, but for which differences cannot be resolved without further research.

Hiking and Riding Behavior

1. Walk or ride on durable surfaces when travelling cross-country. The durability of some surfaces, such as rock and snow are obvious. But recommendations for forests, meadows, tundra, desert, scree slopes, etc. have been divergent. We need an improved understanding of the durability of different environments as surfaces for cross-country hiking. This would also increase the specificity of recommendations about when it is or is not important to stay on existing trails.

Campsite Selection

1. Select resistant sites for camping, either when selecting an undisturbed site or an existing campsite. A type of ecosystem that would make a durable pristine site might not make a durable long-term site. Recommendations (often contradictory) have been made for forest duff, bare ground in forest, grass, dry ground, soil, sand, gravel, beach, streambed, snow, rock, forest, ridgetop, well-drained sites, dry meadow, open forest, vegetation, delicate vegetation, wet places, flowers, timberline and ecotones. We need an improved understanding of the durability of different environments for campingn.

Use of Campfires

1. Build campfires in an appropriate place. Various surfaces have been suggested as most appropriate. An understanding of resistant campsites and the effectiveness of various fire-building techniques should resolve this issue.

Waste Disposal and Sanitation

1. Dispose of human waste properly. Some have suggested the value of surface disposal because that will hasten decomposition; most suggest burial. We need a better understanding of decomposition rates in various locations, including surface disposal vs. burial. This could permit further recommendations on how to minimize the chance of accidental exposure to contamination, other than the obvious suggestions to go far from water and everybody else.

2. Minimize disturbance when disposing of human waste. Some have questioned the practice of digging cat-holes and latrines in environments, such as certain alpine zones, where recovery from disturbance is exceedingly slow. This is also why some have suggested not taking shovels and trowels into the backcountry. An improved understanding of recovery rates of surface excavations, along with an improved understanding of decomposition rates, would shed more light on this issue.

Use of Stock

1. Confine stock on durable sites. Much as we need to learn more about the durability of different environments for cross-country hiking and for camping, we also need to learn more about durable places to confine stock.

2. Confine stock in such a manner that damage is minimized. While it is clear that certain stock-holding techniques, such as tying stock to small trees, are highly damaging, the appropriateness of other options has never been evaluated. Our ability to provide guidelines on how to handle stock would be improved with more information on the impacts caused, under various situations, by alternative stock-holding techniques, such as hobbles, pickets, high lead, etc.

This analysis suggests that there are 14 important techniques that require further research, regardless of whether or not they are controversial. A number of these are interrelated and could profitably be studied simultaneously. This reduces the number of basic research questions to six. Some of these questions are broad, while others are narrow. Some are better understood, at this time, than others and some questions, if answered, are likely to have a more profound effect on improved wilderness conditions than others.

In my opinion these research topics, in order of priority, are:

(1) **The durability of different environments.** We need to evaluate the durability of different environments as places for cross-country hiking, campsites, campfire sites and for holding stock. This research should also be designed to show how quickly impact occurs in different environments; this would provide an understanding of how frequently camps, tents, kitchen areas, etc. should be moved. It should also be designed to compare the impacts caused by different shoe and boot types. This is obviously a broad topic. A fair amount is already known and we are never likely to have all the answers; however, it is important to continually increase our knowledge. This topic is assigned highest priority because this is knowledge that is used almost continually and that is capable of substantially reducing impact.

(2) **Wildlife impacts and the importance of factors that influence amount of impact.** We need to learn about how serious impacts are, where and when they occur, the susceptibility of different species, at different seasons and places, and how amount, frequency, timing and type of use, as well as user behavior, influence amount of impact. This is also a broad topic. We know even less about wildlife disturbance than site durability.

(3) **The effectiveness of alternative campfire-building techniques.** We need to learn about the effectiveness of various techniques in minimizing the impacts caused by campfires. Effectiveness is likely to vary under different conditions, such as type of ground surface, moisture levels, etc. These differences should be examined in the experimental design, as should refinement of techniques, such as watering sod, depths of pits, etc. This topic could be addressed relatively thoroughly, providing definitive guidelines after several years of experimentation in a variety of places.

(4) **The effectiveness of stock holding techniques, rotation of stock and use of supplemental feed in minimizing impact.** We need to experiment with stock holding techniques and various rotation systems. Effectiveness and rotation frequencies will obviously vary between different environments. The effectiveness of using supplemental feed as a means of minimizing damage also should be evaluated. Both the grazing and trampling effects of stock need to be considered. This is a broad topic about which little is known. It is not assigned a higher priority because in most wildernesses few parties bring stock.

(5) **Decomposition rates for human waste in various situations.** We need to examine decomposition rates of surface and buried deposits in various environments. This topic could be addressed relatively thoroughly, providing definitive guidelines after several years of experimentation in a variety of places. Its priority is not high because options for using this information to change behavior are somewhat limited.

(6) **Recovery rates of surface excavations in various environments.** This will provide a better perspective on the desirability of digging cat-holes in places where recovery may be exceedingly slow. This topic could be researched relatively easily and quickly; however, options for changing behavior are limited and the impacts that might be reduced are not highly significant.

RESEARCH QUESTIONS AND APPROACHES

The second part of this document states explicitly, for each of the preceding six research gaps, the research questions that need to be answered and some research approaches for answering these questions. This will provide guidelines for future studies, while leaving flexibility for developing specific methods which are likely to be dependent upon funding levels and the interests and expertise of those doing the research. While I have attempted to be as thorough as possible in my selection of appropriate research approaches, I am certain to have overlooked some fruitful avenues of research.

DURABILITY OF DIFFERENT ENVIRONMENTS

The focus of this research is on the ability of different environments to be walked and camped on before impacts reach the point where they tend to attract further use, leading to the development of permanent trails or campsites. The ability of different environments to support consistent heavy use is not the issue. It is an important topic for wilderness management, but is more relevant to where to locate official trails and campsites than to low impact education.

A considerable body of research exists on the nature of trail and campsite impacts and the factors that influence the nature and amount of such impacts. See Cole (1987) for a review. Therefore, there is no need--as there is for some of these other research gaps--for an initial review of the literature and problem analysis. This has already been done and the specific questions that must be asked are quite well-defined.

Research Questions

(1) Which environments make the most durable cross-country travel routes?

(2) Which environments make the most durable "pristine" campsites?

(3) How rapidly do trails develop in different environments?

(4) How rapidly do campsites develop in different environments?

(5) How does party size influence deterioration rates?

(6) How does type of shoe worn influence deterioration rates?

(7) How does length of stay influence deterioration rates on campsites?

Research Approaches

Experimental trampling. The principal technique for answering these questions will involve applying carefully controlled amounts of trampling to different environments. Deterioration rates can be estimated by identifying trampling intensities beyond which visible impact occurs. The durability of different environments can be assessed by comparing the effects of trampling on different environments. The effect of different shoe types can be assessed by comparing the impacts of different shoe types, while holding trampling intensity and environment constant.

Numerous trampling studies have been conducted, but the methods used have been so diverse that comparability of results is questionable. See Cole (1985) for a review of previous studies and techniques. Simple standardized techniques, that can be applied in a consistent manner by different researchers, need to be developed. Following agreement on a standardized procedure, the next step is to apply the procedure across a broad range of environments and, then, compare results.

Results of such studies should answer questions about the durability of different environments as both cross-country routes and pristine campsites. They should also provide relatively complete answers to questions about how rapidly cross-country trails develop and the impacts caused by different shoe types. They should provide partial answers to questions about how rapidly pristine campsites become developed (i.e., become impacted enough to be readily recognized as campsites) and the effects of party size and length of stay on campsites. Experimental camping and monitoring of pristine campsites will provide more complete answers to these questions.

As much information as possible should be derived from trampling experiments because they are the simplest scientifically sound means of controlling the factors that influence impacts most profoundly. Such studies can be conducted over a short period of time. The desired treatments can be applied with little difficulty and most of the work can be done by a single investigator. The primary drawback is that experimental trampling does not truly simulate camping behavior. This is why it is necessary to complement experimental trampling studies with experimental camping and monitoring of "real" campsites and trail systems.

Experimental camping. Although logistical problems are pronounced, certain answers can only be derived by applying carefully controlled levels of camping to different environments and measuring the effects of this use. The approach is analogous to experimental trampling; however, instead of merely walking back and forth along a path, the treatments involve camping on previously-unused sites. Party size and length of stay can be varied to determine how they influence amount of impact.

If experimental trampling and camping are both conducted in similar environments, it may be possible to calibrate the techniques. For example, a limited study suggests that the effects of one night of camping by a party of 2-3 approximates the effects of 75-150 experimental trampling passes (Cole 1985). If such a calibration could be refined and determined to be consistent across diverse environments, it would mean that experimental camping--the more difficult and costly approach--would only have to be done in a few situations. Experimental trampling could be conducted more widely but results could be applied to camping through calibration procedures. Also, if the effect of party size is constant across different environments, it would only be necessary to study party size influence in a few environments. This could be determined by comparing the effects of parties of differing size in several environments.

Through such studies we could determine how long it takes for variously-sized parties in different environments to create visible impacts likely to attract other users. This information could be used to select the most durable environments for camping. Managers could provide information to visitors so they could determine, for their party size and the environment being used, how long they should stay and how much they need to disperse their activities to avoid impact.

Monitoring of pristine campsites. Certain insights might also be gained by monitoring campsite impacts in places where use levels are very low. Such studies could identify the severity of campsite impacts, how they are changing over time and which environments are being impacted most seriously. The problem with this approach is that use levels and party characteristics are usually unknown. Therefore, effects in different environments may be caused more by differences in amount or type of use than in environmental durability. Moreover, there is little ability to determine the influence of such factors as amount of use, party size and length of stay. Nevertheless, such studies can provide a valuable documentation of these types of impact to supplement the information on influential factors gleaned from the controlled experiments.

Analysis of informal trail systems. In places with informal cross-country trail systems it is possible to assess the durability of different environments. This would involve comparing sections of trail in different environments where it is reasonable to assume that levels of traffic are similar. Because the focus of primary interest is on the initial appearance of trails, rather than the deterioration of established trails, it would be most helpful to work with trail systems in the early stages of development. The ideal situation would be where trails were well-defined in some environments, but not obvious when crossing others. It is not clear how best to quantify differences. Perhaps the best approach would be to assess the proportion of a given environment in which the trail is visible. The limitations of this approach suggest that it would be most useful as a means of testing the conclusions about environmental durability derived from experimental studies.

WILDLIFE IMPACTS

Numerous studies have documented the effects of recreation on wildlife. Most of the work has been on birds and little of it has been conducted in wilderness. Even more than in the case of vegetation and soil impacts, this work fails to build upon itself or to suggest a theoretical framework. Therefore, the first step in dealing with this problem should be to research and write a definitive literature review and problem analysis.

Research Questions

(1) How do different species respond to wilderness recreationists?

(2) How do responses vary with the location of encounters?

(3) How do responses vary with the time of year of encounters?

(4) How do responses vary with other aspects of visitor behavior?

(5) How significant are these responses to the "health" of these populations?

Research Approaches

Literature review and problem analysis. Several reviews of the literature on recreational impacts on wildlife have been conducted (Ream 1979, Hall and Dearden 1984, Boyle and Samson 1985, Kuss et al. 1987, Starkey and Larson 1987). With the exception of Kuss et al. (1987), these have all been anecdotally oriented; they have not attempted to draw generalizations that answer important research questions or provide specific guidelines for low impact behavior. With all of the wildlife research that has been conducted, as well as the moderately voluminous literature specifically on recreational impacts, it should be possible to draw more conclusions about where impact is occurring, what species are involved, how serious the impacts are, where and when disturbance is particularly harmful and, therefore, what behaviors are likely to minimize disturbance. While much of this will have to be based on conjecture and "best guesses" from experts, it would provide, for the short term, better guidance than currently exists and, for the long term, it would point to research that would improve our understanding on these topics.

The most useful approach to such a project would be to analyze the literature, as well as tap the knowledge of those with expertise in wildlife management that have never written about recreational impacts. The project should have three interrelated goals: (1) to provide an interpretive synthesis (more than a compilation) of knowledge; (2) to suggest specific low-impact behaviors and (3) to suggest research needed to fill high priority research gaps.

More specific studies would be suggested by this review and problem analysis. Some obvious high priority approaches can be suggested, however.

Analysis of wildlife responses to different recreational behaviors. There is a voluminous literature on the response of nesting birds to recreational intrusions. There are even quite a few articles on the disturbances caused by researchers. See Boyle and Samson (1983) for bibliographic references. Other types of wildlife have been studied less frequently. More subtle responses to recreationists have been studied in bighorn sheep by Valerius Geist and his students (Macarthur et al. 1982). Heart rates were monitored telemetrically and related to experimentally controlled types of human disturbance. Responses of wildlife to dogs were compared to those caused by humans, for example.

Using a similar approach, it would be possible to study the importance of other variables, such as party size, frequency of disturbance, location of disturbance, time of disturbance, how close animals are approached, etc. Such work holds real promise for improving our understanding of how behavior might be subtly altered to minimize impacts. It would probably be best to study one species under a variety of situations to understand the nature of intraspecific diversity. Then the studies could be expanded to other species to examine the nature of interspecific differences.

Analysis of how disturbance affects population distribution and fecundity and mortality rates. A missing link in most wildlife studies has been an assessment of the significance of observed impacts. How significant is it, for example, if recreationists scare off a herd of bighorns or if an osprey is scared off its nest? What difference does it make if recreationists cause an increase in heart rate?

These are difficult questions to address adequately. We need to find undisturbed populations and study their population characteristics, fecundity and mortality rates, breeding and feeding characteristics, their range and use of habitats. This must be done without disturbing them. Then, by interjecting controlled disturbances, it should be possible to assess the effects of disturbance on the studied population. Changes in range and habitat use can be followed. If animals are forced from better to poorer habitats, it is clear that populations will suffer. Changes in fecundity and mortality rates, sex and age class distributions can also provide hints about the significance of impacts.

Unfortunately, in addition to being costly, such an approach would be controversial and difficult to set up. However, the value of the information likely to be generated suggests that it would be worthwhile searching for situations in which such an approach is feasible.

EFFECTIVENESS OF ALTERNATIVE CAMPFIRE-BUILDING TECHNQIUES

Compared to the preceding topics, this topic is narrowly-focused and readily amenable to being thoroughly researched. The overall goal of such research is to identify the best places to build fires and, for a given situation, the best technqiues for minimizing impact.

Research Questions

(1) What impacts are caused by various types of campfires in different environments?

(2) How do environmental characteristics, such as amount of vegetation, soil moisture level, etc., affect amount of impact?

(3) How do construction and fire-building techniques, such as depth of the firepit (if a pit is dug), thickness of mound (if a mound fire is built), length of time the fire burns, etc., affect amount of impact?

Research Approach

Experimentation with the impacts caused by various types of fire in differing locations. All of these questions can be answered most readily within the context of a series of experiments. The basic approach would be to build fires in various environments, utilizing a variety of techniques. Some of the important general types of techniques include building fires directly on mineral soil and vegetation, in pits dug in mineral soil, duff and vegetation and on mounds of soil on rock, duff and vegetation. Experiments should also be designed to examine the effects of variation in pit dimensions and mound thickness, as well as how sod and soil excavated from the pit is treated. By replicating experiments at various elevations and in different vegetation and soil types, it should be possible to determine how generally applicable results are.

Conditions prior to building the fire need to be measured; they should be remeasured after the fire. The fire should be dismantled and evidence removed. Then, after a period of recovery, conditions should be reexamined. The primary goal of this research is to identify those situations where a fire can be built and dismantled, leaving no evidence of its having been built. Careful attention should be paid to precisely what impacts are measured. Some options include heat flux, changes in the physical, biological and chemical properties of soils and vegetation loss. Some guidance on techniques and impacts to measure can be found in Fenn et al. (1976), who studied the effects of large campfires on soil. Some quantification of visual evidence remaining after a period of recovery also seems desirable. Finally, if any areas away from the fire are disturbed, such as a source of soil for a mound fire, long term changes there should also be assessed.

RECREATIONAL STOCK IMPACTS IN GRAZING AREAS

Although information on the impacts and management of packstock throughout the wilderness would be helpful, the highest priority is an improved understanding of their impacts in grazing areas near campsites (places where stock are allowed to graze and are kept during overnight stays). Stock impacts on established trails and campsites are usually similar in nature to those caused by hikers, although they are more pronounced. Recreational impacts to grazing areas are caused exclusively by packstock, however, and we know very little about them. Because we know so little about these impacts, this is another topic for which an interpretive review of literature and problem analysis would be useful.

Research Questions

(1) What are the impacts of trampling and grazing on vegetation, soils, wildlife and water?

(2) How do impacts vary with use characteristics, such as amount, frequency and timing of use?

(3) How do impacts vary with environmental characteristics, such as meadow type, productivity, moisture, etc.?

(4) How can rotation of stock be used to minimize impact and how should rotation techniques and frequency vary under different use and environmental situations?

(5) How can use of supplemental feed minimize impact and how should use of feed vary under different use and environmental situations?

(6) How effective are various constraining methods (e.g. pickets or hobbles) in minimizing impact under different situations?

Research Approaches

Literature Review and Problem Analysis. Given the virtually complete absence of rigorous work on this topic, it will be some time before we get adequate answers to these questions. Consequently, there would be considerable value in attempting some "best guesses" on some of these, particularly as they relate to the effectiveness of behaviors in minimizing damage. There is a voluminous literature and considerable body of expertise on range management, even if little of it has been applied to wilderness management. This could be tapped to provide partial answers to these questions, to develop guidelines for low-impact use and to identify the most productive avenues of research. Although such a review would identify the most important research topics, several obvious approaches can be described at this stage.

Analysis of the effects of amount, timing and frequency of use on different vegetation types. This complex topic could best be handled through a series of experiments, designed to examine each of these variables while the others are controlled. These experiments would need to be conducted in places where use could be controlled. It would be informative to conduct them in both previously undisturbed places and places that have been grazed before. The basic approach would involve taking measurements before and after treatment, both on treated places and untreated controls. Treatments would include different numbers of stock, frequencies of grazing and seasons of use. By conducting experiments in different vegetation types or under different environmental conditions, the influence of these differences on impacts could also be assessed. Such impacts as vegetation loss, changes in species composition and soil compaction should be examined. Recovery following removal of grazing should also be followed.

The results of such studies would aid managers in the identification of use thresholds above which impacts become unacceptable. They should identify seasons when use is either particularly harmful or not. And they should determine how the distribution of use over time, whether concentrated or spread out, affects amount of impact. Finally, results should permit the identification of differences in the ability of vegetation types to support stock use and environmental factors, such as moisture levels, that influence environmental durability.

Experimentation with rotation and supplemental feeding of stock. These studies would be similar in approach to the preceding ones. In this case, the amount and temporal distribution of use would be held constant. The independent variables of primary interest are how frequently stock are rotated within specific meadows and how much supplemental feed they are given. The effectiveness of rotation and supplemental feeding strategies would clearly depend upon both use and environmental characteristics. Consequently, these series of experiments would have to be conducted in both high and low use situations, as well as in various vegetation types.

Experimentation with stock constraining methods. These studies would also hold amount and temporal distribution of use constant; in this case the methods of constraining stock would be varied. Techniques to experiment with include pickets, hobbles, hitch lines and corrals. Conditions would be compared before use, after use, and after a recovery period. Again, these experiments would have to be conducted in both high and low use situations, as well as in various vegetation types.

Analysis of the severity of competition for forage between stock and wildlife. There are a handful of wildernesses where substantial stock grazing occurs on important winter range. If excessive, this competition could adversely affect wildlife populations. A good example for study would be the effects of heavy grazing of winter range along the South Fork of the Flathead River and its tributaries on the elk population in the Bob Marshall Wilderness. Such a study would require analysis of both the feeding habits and requirements of wildlife and the consumption of forage by stock. It would be important to identify both where competition is occurring and whether or not this is having an adverse effect on the wildlife.

DECOMPOSITION RATES FOR HUMAN WASTE

This topic is quite focused, making it likely that research questions could be answered relatively thoroughly. There is little need for literature review or problem analysis. The overall goal of the research is to identify the best places to deposit human waste, such that it is rendered innocuous in as short a period of time as possible. This information could then be combined with the more obvious concerns for avoiding human contact and water pollution.

Research Questions

1. How rapidly do human waste and pathogenic organisms therein decompose in different environments?
2. How do decomposition rates vary between surface deposition and burial?

Research Approach

Experimentation with decomposition rates for human feces and pathogens in different environments. A series of experiments by Ken Temple and his students (see, for example, Temple et al. 1982) found that large quantities of pathogens in feces survived burial for a year on a mountain in Montana. They found little difference in survival related to vegetation type or depth of burial. However, they did speculate that survival would probably have been less with surface disposal of the feces. Similar experiments in very different regions should be conducted to determine the general applicability of these results. Both decomposition of feces (to the point where it is no longer visually objectionable) and death of pathogens should be monitored for both surface disposal and burial. This information should form the basis for generalizations about desirable features of a human waste disposal site--other than being away from others and from surface water.

RECOVERY RATES OF SURFACE EXCAVATIONS

In alpine soils, holes dug to deposit human waste (or for any other reason) often do not recover. This calls into question the desirability of digging holes for any reason in these places. This topic is narrowly-focused and there is no need for extensive review or problem analysis. The limited applicability of results suggests that this project should have a much lower priority than the others.

Research Question

(1) How rapidly do surface excavations recover in different environments?

Research Approach

Experiment with surface excavations in different environments. The approach to use here would simply involve digging holes in the soil in various vegetation and soil types, replacing excavated material, and monitoring changes over time. Alpine environments should be the primary focus of attention, but research could also be conducted in other ecosystem types. These experiments may have to be conducted over many years, where recovery is an extremely slow process, but the amount of time required each year need not be great.

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APPENDIX

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